

We Claim:

1 1. In a graphics system including a graphics processing pipeline that
2 renders and displays images at least in part in response to primitive vertex data and
3 texture data, a texture processing system for mapping a texture to a surface of a
4 rendered image object, said texture processing system comprising:

5 a texture coordinate/data processing unit that interleaves processing of
6 logical direct and indirect coordinate data;

7 a texture data retrieval unit connected to the coordinate/data
8 processing unit, the texture data retrieval unit retrieving texture data; and

9 a data feedback path from the texture data retrieval unit to the texture
10 coordinate/data processing unit to allow reuse of the texture coordinate/data
11 processing unit in the same rendering pass;

12 wherein in response to a set of indirect texture coordinates the
13 retrieval unit recirculates retrieved texture data back to the processing unit for
14 deriving modified texture coordinates which are used in mapping a texture to a
15 surface of a rendered image object.

1 2. The graphics system as set forth on claim 1 wherein the texture
2 coordinate/data processing unit further comprises a set of hardware control logic
3 registers coupled to data lines in the pipeline for receiving data and processing
4 command information used to initiate indirect texture referencing and to control
5 multiplication and addition operations for deriving said modified texture
6 coordinates.

7 3. In a graphics system having a memory containing texture data, a
8 method of indirect texture referencing comprising the steps of:

9 (a) using indirect texture coordinates to generate a data triplet;

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1 10. A method of indirect texture referencing as in claim 3 wherein a
2 triplet comprises three five-bit binary values.

1 11. A method of indirect texture referencing as in claim 3 wherein a
2 triplet comprises three four-bit binary values.

1 12. A method of indirect texture referencing as in claim 3 wherein a
2 triplet comprises three three-bit binary values.

1 13. A method of indirect texture referencing as in claim 3 wherein a
2 quadruplet of indirect texture coordinates are processed together to produce a
3 quadruplet of derived texture coordinates for mapping texture data to polygons.

1 14. A method of indirect texture referencing as in claim 7 wherein said
2 first matrix comprises elements that are a scalar function of one or more
3 predetermined texture coordinates.

1 15. A method of indirect texture referencing as in claim 7 wherein said
2 first matrix is a 3 X 2 matrix comprising six predetermined scalar elements.

1 16. A method of indirect texture referencing as in claim 7 wherein said
2 first matrix is arranged having elements as follows:

$$\begin{pmatrix} s/256 & t/256 \\ 0 & 0 \\ 0 & 0 \end{pmatrix}$$

4 wherein s and t are predetermined texture coordinates.

1 17. A method of indirect texture referencing as in claim 7 wherein said
2 first matrix is arranged having elements as follows:

$$\begin{pmatrix} 0 & 0 \\ s/256 & t/256 \\ 0 & 0 \end{pmatrix}$$

4 wherein s and t are predetermined texture coordinates.

1 18. In a 3D videographics system having a memory containing texture
2 data stored in a texture memory, the texture data accessed via either a set of direct
3 texture coordinates or a set of indirect texture coordinates, a method of indirect
4 texture referencing for mapping a predetermined texture onto a polygon
5 comprising the steps of:

6 (a) using a set of indirect texture-coordinates to retrieve a data triplet
7 stored in texture memory;

8 (b) deriving a set of modified texture coordinates based at least in part
9 on the retrieved data triplet; and

10 (c) using the set of modified texture coordinates to reference texture
11 data stored in texture memory corresponding to the predetermined texture.

1 19. A method of indirect texture referencing as in claim 18 wherein the
2 deriving step (b) includes performing at least one matrix multiplication operation
3 wherein a first matrix comprising a plurality of predetermined constant and/or
4 variable scalar elements is multiplied by a second matrix comprising a retrieved
5 data triplet.

1 20. A method of indirect texture referencing as in claim 18 wherein the
2 using step (c) includes referencing, in a texture memory, an array that maps color
3 value data via the derived texture coordinates.

1 21. A method of indirect texture referencing as in claim 18 wherein a data
2 triplet comprise at least one texture coordinate offset.

1 22. A method of indirect texture referencing as in claim 18 wherein a data
2 triplet comprises s, t, and u texture coordinate offset values.

1 23. A method of indirect texture referencing as in claim 18 wherein a data
2 triplet comprises three eight-bit binary values.

1 24. A method of indirect texture referencing as in claim 18 wherein a data
2 triplet comprises three five-bit binary values.

1 25. A method of indirect texture referencing as in claim 18 wherein a data
2 triplet comprises three four-bit binary values.

1 26. A method of indirect texture referencing as in claim 18 wherein a data
2 triplet comprises three three-bit binary values.

1 27. A method of indirect texture referencing as in claim 19 wherein said
2 first matrix comprises elements that are a scalar function of one or more
3 predetermined direct texture coordinates.

1 28. A method of indirect texture referencing as in claim 19 wherein said
2 first matrix is a 3 X 2 matrix comprising six predetermined scalar elements.

1 29. A method of indirect texture referencing as in claim 19 wherein said
2 first matrix is arranged having elements as follows:

$$\begin{pmatrix} s/256 & t/256 \\ 0 & 0 \\ 0 & 0 \end{pmatrix}$$

4 wherein s and t are predetermined current direct texture coordinates.

1 30. A method of indirect texture referencing as in claim 19 wherein said
2 first matrix is arranged having elements as follows:

$$\begin{pmatrix} 0 & 0 \\ s/256 & t/256 \\ 0 & 0 \end{pmatrix}$$

4 wherein s and t are predetermined current direct texture coordinates.

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31. In a graphics system including a graphics processing pipeline that renders and displays images at least in part in response to polygon vertex data and texture data stored in a memory, the graphics processing pipeline having a texture subsystem for accessing and retrieving texture. the texture subsystem comprising a texture coordinate/data processing unit having: a) at least one binary data multiplier, at least one binary data accumulator and at least one control register for receiving instruction codes and/or data to control texture coordinate/data processing operations, b) a texture data retrieval unit connected to the coordinate/data processing unit, the texture data retrieval unit retrieving texture data stored in a texture memory, and c) a data feedback path from the texture data retrieval unit to the texture coordinate/data processing unit to recycle retrieved texture data through the texture coordinate/data processing unit for further processing, wherein in response to a set of indirect texture coordinates the retrieval unit provides retrieved texture data to the processing unit for deriving modified texture coordinates, a method for controlling the texture subsystem to perform one or more indirect texture referencing operations comprising the step of utilizing a generalized indirect-texture referencing API command function to place appropriate instruction codes and/or data in said control register(s), wherein said indirect-texture referencing function may be used to at least:

- (i) define up to eight textures stored in a texture memory;
- (ii) specify up to eight sets of texture coordinates;
- (iii) define up to four indirect texture maps;
- (iv) specify up to four indirect texture referencing operations to be performed;

25 (v) associate one of said eight textures with each indirect texture map;
26 and

27 (vi) associate one of said eight sets of texture coordinates with each
28 indirect texture maps.

1 32. In a graphics system having a memory containing texture data, a
2 method of indirect texture referencing comprising the steps of:

3 (a) using a set of indirect texture-coordinates to retrieve offset data
4 from the memory;

5 (b) multiplying the offset data by predetermined values forming
6 elements of a texture offset matrix to produce a set of texture offset coordinates;
7 and

8 (c) using said set of offset texture coordinates for referencing texture
9 data stored in the memory when mapping a predetermined texture to a rendered
10 polygon.

1 33. A method of indirect texture referencing as in claim 32 wherein said
2 offset data is a result of a predetermined texturing function and comprises at least
3 one texture coordinate offset value.

1 33. A method of indirect texture referencing as in claim 32 wherein said
2 offset data comprises a set of three values for producing said set of texture offset
3 coordinates.

1 34. A method of indirect texture referencing as in claim 33 wherein said
2 set of three values comprise s, t and u coordinate offset data.

1 35. A method of indirect texture referencing as in claim 32 wherein said
2 matrix elements comprise a set of predetermined constants.

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1 31. In a graphics system including a graphics processing pipeline that
2 renders and displays images at least in part in response to polygon vertex data and
3 texture data stored in a memory, the graphics processing pipeline having a texture
4 subsystem for accessing and retrieving texture, the texture subsystem comprising a
5 texture coordinate/data processing unit having: a) at least one binary data
6 multiplier, at least one binary data accumulator and at least one control register for
7 receiving instruction codes and/or data to control texture coordinate/data
8 processing operations, b) a texture data retrieval unit connected to the
9 coordinate/data processing unit, the texture data retrieval unit retrieving texture
10 data stored in a texture memory, and c) a data feedback path from the texture data
11 retrieval unit to the texture coordinate/data processing unit to recycle retrieved
12 texture data through the texture coordinate/data processing unit for further
13 processing, wherein in response to a set of indirect texture coordinates the retrieval
14 unit provides retrieved texture data to the processing unit for deriving modified
15 texture coordinates, a method for controlling the texture subsystem to perform one
16 or more indirect texture referencing operations comprising the step of utilizing a
17 generalized indirect-texture referencing API command function to place
18 appropriate instruction codes and/or data in said control register(s), wherein said
19 indirect-texture referencing function may be used to at least:

20 (i) define up to eight textures stored in a texture memory;

21 (ii) specify up to eight sets of texture coordinates;

22 (iii) define up to four indirect texture maps;

23 (iv) specify up to four indirect texture referencing operations to be
24 performed;

1 36. A method of indirect texture referencing as in claim 32 wherein said
2 matrix elements comprise a set of constant and variable values.

37. A method of indirect texture referencing as in claim 32 wherein one or more elements of said matrix are a mathematical function of one or more predetermined texture coordinates.

38. A method of indirect texture referencing as in claim 32 wherein the matrix is a 3 X 2 matrix comprising six predetermined scalar elements.

39. A method of indirect texture referencing as in claim 32 wherein the matrix is arranged having elements as follows:

$$3 \quad \begin{pmatrix} s/256 & t/256 \\ 0 & 0 \\ 0 & 0 \end{pmatrix}$$

4 wherein s and t are predetermined current direct texture coordinates.

40. A method of indirect texture referencing as in claim 32 wherein the matrix is arranged having elements as follows:

$$3 \quad \begin{pmatrix} 0 & 0 \\ s/256 & t/256 \\ 0 & 0 \end{pmatrix}$$

4 wherein s and t are predetermined current direct texture coordinates.

41. In a graphics system including a graphics engine that renders and displays images at least in part in response to polygon vertex data and texture data stored in an associated memory, a texture processing subsystem for selectively mapping texture data corresponding to one or more different textures and/or texture characteristics to surfaces of said rendered and displayed images, said texture processing subsystem including a texture coordinate offset matrix

7 arrangement producing a set of offset texture coordinates by multiplying indirect
 8 texture data by elements of a matrix, wherein one or more elements of the matrix
 9 are a mathematical function of one or more predetermined direct texture
 10 coordinates.

1 42. A texture processing subsystem as in claim 41 wherein the matrix has
 2 six elements in three rows and two columns.

1 43. A texture processing subsystem as in claim 41 wherein the matrix is
 2 arranged having elements as follows:

$$\begin{pmatrix} s/256 & t/256 \\ 0 & 0 \\ 0 & 0 \end{pmatrix}$$

4 wherein s and t are predetermined current direct texture coordinates.

1 44. A texture processing subsystem as in claim 41 wherein the matrix is
 2 arranged having elements as follows:

$$\begin{pmatrix} 0 & 0 \\ s/256 & t/256 \\ 0 & 0 \end{pmatrix}$$

4 wherein s and t are predetermined current direct texture coordinates.

1 45. In a graphics system including a graphics engine that renders and
 2 displays images at least in part in response to vertex data and texture data stored in
 3 an associated memory, a texture processing subsystem for selectively mapping
 4 texture data corresponding to one or more different textures and/or texture
 5 characteristics to surfaces of said rendered and displayed images, said texture
 6 processing subsystem including a texture coordinate offset matrix arrangement for
 7 producing a set of offset texture coordinates by multiplying indirect texture data by

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1 46. A texture processing subsystem as in claim 45 wherein said elements
2 are predetermined constants.

1 48. A texture processing subsystem as in claim 45 wherein the matrix has
2 six elements in three rows and two columns.

3 (a) using a set of indirect texture coordinates to retrieve texture offset
4 data from memory, said offset data being a result of a predetermined texturing
5 function and comprising at least one texture coordinate offset value;

8 (c) using said set of offset texture coordinates for referencing
9 predetermined texture data in memory.

51. A method of indirect texture referencing as in claim 49 wherein said
offset data comprise a set of three eight-bit binary values.

1 52. A method of indirect texture referencing as in claim 49 wherein said
2 offset data comprise a set of three five-bit binary values.

1 53. A method of indirect texture referencing as in claim 49 wherein said
2 offset data comprise a set of three four-bit binary values.

1 54. A method of indirect texture referencing as in claim 49 wherein said
2 offset data comprise a set of three three-bit binary values.

1 55. In a graphics system having a memory containing texture data stored
2 in a texture memory, the texture data accessed using either a set of direct texture-
3 coordinates or a set of indirect texture-coordinates, a method of implementing
4 multiple levels of indirection during indirect texture referencing for mapping a
5 texture onto a primitive, comprising the steps of:

6 (a) using a set of indirect texture-coordinates to retrieve data triplets
7 stored in texture memory;

8 (b) deriving a set of modified texture coordinates based at least in part
9 on the retrieved data triplets;

10 (c) using the set of modified texture coordinates for retrieving data
11 stored in texture memory;

12 (d) reiteratively repeating steps (b) and (c) for a predetermined
13 number of data retrievals; and

14 (e) using a set of derived texture coordinates resulting from step (d) to
15 map predetermined texture data onto the primitive.

1 56. In a graphics system including at least one texture mapping unit, a
2 method of operating the texture mapping unit to provide a plurality of logical
3 texture mapping stages comprising:

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4 (a) presenting a first set of texture mapping parameters to the texture
5 mapping unit;

6 (b) controlling the texture mapping unit to perform a first texture mapping
7 operation in response to said parameters presented by step (a);

8 (c) recirculating results of step (b) to develop a further set of texture
9 mapping parameters; and

10 (d) presenting said further set of parameters to the texture mapping unit and
11 controlling said texture mapping unit to perform a further texture mapping
12 operation in response to said further set of parameters.

1 57. The method of claim 56 wherein step (b) includes performing an
2 indirect texture mapping operation that develops a data set, recirculating step (c)
3 comprises developing a further set of texture mapping parameters responsive to
4 said developed data set; and step (d) includes performing a direct texture mapping
5 operation in response to the further set of texture mapping parameters.

1 58. The method of claim 56 wherein the developing step develops said
2 further set of texture mapping parameters by combining a further set of direct
3 texture coordinates with said data set.

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